REMARKS

ON THE

NATURE OF ENERGY,

AND

THE CORRELATION AND TRANSMUTATIONS OF ITS VARIOUS PHYSICAL FORMS;

BEING THE INTRODUCTORY CHAPTER TO A NEW EDITION OF

THE ELEMENTS

OF

NATURAL PHILOSOPHY.

BY

CHARLES BROOKE, M.A., F.R.S., PR.M.S.,

LATE PR. R. M. S., ETC.

LONDON:

JOHN CHURCHILL & SONS, NEW BURLINGTON STREET.

MDCCCLXVII.

INTRODUCTION.

ON THE NATURE OF ENERGY, AND THE CORRELATION AND TRANSMUTATIONS OF ITS VARIOUS PHYSICAL FORMS.

As the terms "force" and "energy," with their qualifying adjuncts, "actual" and "potential," will, in the following treatise, be definitely employed, it may be as well, *in limine*, to define the terms themselves. The term *energy* means simply the power of doing work; *force* means the power of producing energy. These terms have been frequently confounded together; thus we are accustomed to speak indifferently of the force of the powder, and the "force" of the shot. But this is one of those confusions of terms, that is very likely to lead to a confusion of ideas: strictly speaking, the powder has force, the shot only energy. Again, the force of the powder is only *potential*, or capable of being called into activity, while it remains yet unignited; but on the moment of ignition, its force becomes *actual*. Again, while the raised steam-hammer reposes tranquilly on its soft cushion of steam, the force of gravity in the one is counteracted by elastic force in the other, and the energy of the hammer is *potential* only; but when the cushion is withdrawn, that energy soon becomes destructively *actual*. The term "actual" is not constantly employed, but may always be implied in the absence of the qualifying adjunct, "potential:" and moreover, the term, potential, is frequently employed elliptically for potential energy, thus we speak of the potential of an electric charge, or of a voltaic current.

While speaking of the relations of force and energy, it may be well to notice, in reference to the sequel of this work, a radical and misleading error that has found its way into some elementary treatises on Physics, that of including *time* as an element of an unit of work, or dynamic unit, or foot-pound, as it is commonly estimated in this country. The Author has noticed the foot-pound defined as the force required to raise one pound through the height of one foot *in one second*. Now the insertion of the last clause of the definition is worse than useless; it is mischievous, because it is misleading;—the definition should

involve the *amount* of work only, which is wholly irrespective of the length of time occupied in doing it.

The inevitable tendency of the comparison of innumerable carefully observed and recorded facts, revealed by modern physicists, is to satisfy and convince the reflecting mind of the unity and universality of force, and thence to guide the mental vision (unless it be obscured and distorted by the false pride of human reason) to the unity of that Almighty power by whose arm universal force is wielded.

It is a difficult thing to dislodge ideas from the deeply-worn grooves, in which they have long and perhaps smoothly run; but the writer cannot doubt that ere long all the physical phenomena, that are amenable in all their endless variety to our senses, will be acknowledged to be the results or effects of various but interchangeable modifications of energy. And there can be probably as little doubt, that the universal medium of communication between mind and matter, the means by which the impressions of external things are *one and all* rendered cognizable to the senses, is *wave-motion*, excited in the molecules of palpable matter.

With regard to the functions of the eye and ear, the application of this law is not less evident, than universally acknowledged, provided electricity and magnetism be admitted (as they must be) into the category of wave-motions.

The sense of touch or feeling is awakened only by actual contact or impact, or by the closely-allied wave-motions of heat and electricity, *i.e.*, by dynamic, thermic, or electric energy; and the amount of sensuous impression is progressive from the lightest touch to the actual tearing asunder of the nerve filaments by saw-teeth (for the edge of the keenest razor is nothing more than a saw), and the mode of excitation may, in this case, be roughly symbolized by the action of a bow on a stretched chord. But in physiological as in physical dynamics (279) time frequently enters in as an important element, for relatively considerable time is occupied by the transit of electric motion along the nerves (1003), this transference being probably in analogy with that of thermic motion by conduction, whereas electric induction is probably more in analogy with thermic radiation. Thus also in a rapid stroke of a keen cutting instrument, or in the rapid motion of a bullet through the living tissues, the impression on the nerves may be too sudden for transmission: just as the damage to a sheet of glass by a rifle shot is confined to the point of impact, while the glass is shivered into a thousand pieces by the far less energetic impact of a stone, or a brickbat.

Again, the sense of itching or tingling is excited by the frequent repetition of very slight impulses either of dynamic, thermic, or electric energy; and the intensity of the sensation (when intense more intolerable than even actual pain) is proportioned not to the *energy* of each impression, but to their *frequency*. The excessive

tingling of the so-called "foot asleep" at the moment of the restoration of unimpeded fluid motion through the capillary vessels is notorious.

The dependence on wave-motion of the closely allied senses of taste and smell may be not less readily indicated. Very cold substances are notoriously tasted and smelt with difficulty, and the sensibility of the terminal loops of the olfactory and gustatory nerves is considerably impaired by cold: for example, odours are less perceptible on a very cold day, when the olfactory surfaces are chilled by respiration; and the senso of taste is notoriously impaired when the gustatory surfaces of the mouth are chilled by ice. Thus it appears that the sensuous impressions of smell and taste are influenced quantitatively by temperature, *i.e.*, by the amount of thermic energy. But as to qualitative influence nothing is known with certainty: the minute anatomy of the heat spectrum is a much more inscrutable subject than that of the spectrum of light; but for all that is known to the contrary, the odours of the rose and the violet may be due to relatively *red* and *violet* rays of the heat-spectrum impinging upon "resonant" or reciprocating vapours, which are capable of taking up and imparting to the sentient nerve-fibres their own peculiar periods of wave-motion. It may perchance be, moreover, that to the naturally acute and highly cultivated olfactory sensibility of a Rimmel, the "Harmony of Perfumes" is as much a reality, as the harmony of colours to the eye of the painter, or the harmony of sweet sounds to the musician's ear: these several faculties being alike acute perceptions of vibratory congruencies. It may then with much probability bo assumed, that the universal means of exciting sensuous impressions is wave-motion.

The universality of wave-motion as the connecting link between mind and matter, having been thus premised, the nature of the motion resulting from each recognised form of energy becomes an interesting subject of investigation. In the waves of sound the direction of the displacement of each vibrating particle is demonstrably longitudinal, or coincident with tho direction of the wave (Ch. X.). In the waves of light and heat that displacement is inferentially proved to be transverse by the phenomena of refraction, diffraction, interference, and polarization (Ch. XIX. and XXI.), which are wholly inexplicable on any other hypothesis. It will appear in the sequel that there exist valid grounds for assuming electricity, and consequently magnetism, to be forms or modes of wave-motion, and further that at all events the magnetic wave is a spiral, the path of each disturbed particle being probably a circle in a plane to which the direction of the wave is a normal.

The principle of the "conservation of energy" implies that when once actual energy has been developed in matter it cannot be annihilated, it can only be transferred in some form to other matter. So universal is the truth and practical application of this

principle of conservation that it may almost be taken as an axiom, that it is no more within the narrowly bounded power of man to create or annihilate *force* or *energy*, than it is to create or annihilate *matter* itself: energy may be variously transmuted and directed, and matter may be variously combined and modified in form and physical properties, but that is all. This principle has been so ably advocated by Mr. Grove in his "Correlation of Physical Forces," and by others elsewhere, and will be found so repeatedly illustrated in the following pages, that it will suffice here to mention a few examples that have more recently been presented to notice. The writer has clearly shown the interchange of thermic and dynamic energy at the point of junction of the bars of a thermo-electric element of antimony and bismuth (972), and he has also pointed out (997) that the dynamic nature of electric energy is not less clearly indicated by the long known fact that an ordinary voltaic current always commences with a rush, as it were, the instant that the circuit is closed. The dynamical cause of this is clearly pointed out by an experiment due to the genius of Prof. Wheatstone. If a tuning-fork, the tail of which is inserted longitudinally into a wooden handle, like a file or chisel, be made to vibrate, and the end of the handle rested obliquely on a table, the resonance of the table will instantly be heard, but on moving the diapason parallel to itself in any direction on the table, the resonance ceases, from the perpetual interference of the successive planes of vibration with each other. But now comes the illustration:—On arresting the motion of translation the resonance immediately recommences, but with a rush or momentary increase of sound: this must unquestionably arise from the resistance offered by the inertia of the molecules of wood to the commencement of wave motion; and the parallel phenomenon in electricity may undoubtedly be similarly accounted for. And the momentary reflex current (the terminal extra current of Faraday), which is well known to take place at the instant of opening the circuit, is equally susceptible of a dynamic interpretation; it is the analogue of the wave reflected from the fixed end of a stretched chord, after having been imparted by the hand to the free end.

The dynamic nature of electric energy is clearly indicated by the dynamo-electric* machine of Holtz (701), in which dynamic is directly converted into electric energy, and by the cognate machines of Wilde (911), Wheatstone,† Siemens,† and Ladd,‡ in

* The Author has elsewhere applied (p. 550, *note*) a definite and intelligible meaning to the construction of these compound terms, which must be constantly employed in relation to the conversions of energy; this may be accomplished by taking the first section of the term to mean the *acting cause*, the second, the *resulting effect;* thus a dynamo-electric machine will be one in which dynamic energy is employed to produce an electric current, and an electro-dynamic engine, one in which a current is employed to evolve dynamic energy.

† Proceedings of the Royal Society, Feb. 1867. ‡ Ib. March, 1867.

all of which alike there is an intervening conversion of dynamic into magnetic energy. The enormous amount of current-energy evolved in Mr. Wilde's machine, when the power of a steam-engine is employed to rotate the armatures, may be judged of by the fact that a long piece of platinum wire 0·2 inch in thickness was seen to be disintegrated and partially fused. It is difficult to conceive that in these instances dynamic energy can be converted into magnetic "fluid," and that again into thermic energy: the conversion of motion into matter, and the subsequent reconversion of matter into motion, is obviously impossible.

Some further consideration of the effects of electric energy may serve to indicate the probable nature of the wave-motion. The facts of electric and magnetic polarity imply and necessitate a polarity or directionality in the motion itself, which has no analogue in the waves of sound, light, or heat. This requirement is fully met by the hypothesis of a circular spiral wave, analogous to that of a pencil of circularly polarized light, the motion of which is direct or positive if viewed from one end, and retrograde or negative if from the other; and this suffices to explain the well-known polarity of electric and magnetic induction.

Thus far the spiral hypothesis is merely inferential, but in regard to magnetic wave-motion some strong presumptive evidence may be adduced. It appears from the experiments of Mr. Joule, made more than twenty years ago, that if a suspended mass of copper be, by twisting the suspension, made to rotate between the poles of an unexcited electro-magnet, the rotation of the mass is arrested the instant the magnet is excited; and furthermore, if the mass be forcibly rotated, heat is developed in it. And it has been since ascertained that if two cylindrical magnets be so placed that their axes lie in the same straight line, and their contrary poles are opposed to each other, then if a cylinder of copper be made to rotate on its own axis, coinciding with the common axis of the magnets, no heat will be evolved by its rotation.

Now these phenomena must alike be the necessary consequences of the assumed dynamical theory; for if the copper molecules be thrown into spiral-wave motion, then the motion of all the disturbed particles will be one of revolution in planes to which the lines of magnetic force are normals: and the inertia, or energy, of rotation (as it has been variously termed), *i.e.*, the resistance offered by each revolving particle to any change in the direction of its plane of revolution (as exemplified by the gyrascope), will resist the rotation of the mass in any direction perpendicular to that of the axes of molecular revolution, and arrest its motion. And conversely, if the mass be forcibly rotated in the above direction, or in any other direction at right angles to the lines of magnetic force, heat will be freely developed, doubtless by internal friction arising from the perpetual displacement of the planes of molecular revolution. But in the second case, the axis of rotation of the

mass coincides in direction with those of the axes of molecular revolution, hence there is no displacement of the molecular orbits, and consequently no internal friction, and very little if any heat is generated.

The rotatory character of the magnetic wave is further confirmed by the known fact that if a plane polarized beam pass through a transparent solid in the direction of the lines of force of a powerful electro-magnet, the plane of polarization will be rotated the instant that the magnet is excited. The truth of a theory can be established only by the verification of its necessary consequences; and it may not be too much to assume that in the present case the evidence already adduced by the writer is, in the entire absence of all contradictory evidence, strongly presumptive of the reality of the hypothesis.

It has been authoritatively stated that ordinary electric and magnetic waves *cannot both* be assumed to be spirals, because each of these forms of energy notoriously evolves the other in a direction perpendicular to its course; and the question is not without grave dynamical difficulties, but they may perhaps not be insuperable. It may possibly be that from some unknown constraining condition or property inherent in magnetic bodies, a spiral wave, on being constrained into a spiral course, may lose its original spirality, and become a secondary spiral, having molecular motion in a direction perpendicular to that of the primary spiral.

The relation between the various modes of motion, their physical results, and the sensuous perception of those results, having thus been inferred, the question next arises as to the nature of the media by which the several modes of motion are transmitted. It is unquestionable that sound-waves are transmissible by all kinds of matter, but can any valid reason be assigned in favour of the still prevalent opinion that other modes of wave-motion are incapable of transmission by ordinary matter?—this incapacity being implied in the adoption of the self-contradictory hypothesis of an imaginary medium, not cognizable by any known means of perception. It is a remarkable fact that in all the superseded crude notions of physical causation, each phase of physical energy has been presented in the garb either of impalpable, imponderable (in fact *immaterial*) matter itself, or of the vibrations thereof; and each of these hypotheses has been successively subjected to some violent supplementary hypothesis, in order adequately to meet the requirements of advancing knowledge.

To begin with chemical action:—What are now universally recognised as simple metals were once supposed to consist of some earthy matter (their oxides) combined with "Phlogiston,"—the *material* principle of brilliancy. But, unfortunately for the theory, it was soon found that the metals, on parting with their share of

phlogiston (*i.e.*, becoming oxidated), not only did not *lose* any, but actually *acquired* weight; therefore phlogiston was assumed to be not only *imponderable*, but *hyper*-imponderable—*i.e.*, endowed with the property of absolute levity, or negative weight!

In the next place, the Newtonian theory of light assumed light to consist of molecules (of course *imponderable*) emanating from the source of light, and impinging on the perceptive organs of vision. But this hypothesis would not fit the phenomena of diffraction (1125) and interference (1121), and to suit these physical facts, the molecules must either be thrown into periodical "fits" of transmission or reflection, or the ray must be a row of egg-shaped molecules perpetually making isoperiodic somersaults, and plunging into a medium if they come on their heads, or bounding off, if they fall sideways against it. Then again, heat was supposed to consist of material particles emanating from the source of heat; and as a ball of ice placed in one focus of a concave mirror was found to lower the temperature of a thermometer placed in the conjugate focus, there were assumed to be particles of *cold*, as well as of *heat*: it is needless to add how completely the theory of exchanges (1392) accounts for the latter fact. At length these wild speculations were superseded, and light and heat were admitted into the category of wave-motion; but electricity and magnetism were still supposed to be either single or dual forms of "fluid" matter: and

"Saxa etiam molli dura teruntur aquâ:"

these "fluids" are probably still running in the deep channels they have worn in some philosophic minds.

But the principle of admitting imponderability into the category of legitimate physical hypotheses had become tacitly accepted; and the conclusion was at once jumped at by the authors of the undulatory theory that the wave-motions of light and heat take place in an imperceptible, *imponderable*, highly elastic fluid medium, pervading all space, *and all matter*, denominated "ether:" and this theory, with all its inconsistencies and inconsequences, is still probably entertained by many physicists.

That some highly elastic and attenuated medium pervades infinite space, as the means of transmission of the energies of light and heat from the centre of each solar system to its dependent satellites, is a necessary consequence of the dynamic theory: its existence is, in fact, demonstrated by the periodic retardation of Encke's Comet. But the *remainder* of the hypothesis, namely, that all palpable matter is pervaded by ether, for the purpose of transmitting light- and heat-waves is by no means equally necessary, or even tenable; for not a shadow of evidence of the inadequacy of all matter to transmit these motions has ever been produced,

and in default of such evidence, the contrary hypothesis is at least equally tenable; and this interstitial-ether theory (in common with all preceding physical theories involving imponderability) is burdened with grave inconsistencies. In the first place the well-known phenomena of single and double refraction and polarization, whether of light or heat, necessitate the somewhat violent hypothesis that the elasticity of the supposed transmitting medium, ether, is not, as it is in all cognizable fluids, a fixed and definite quality capable of numerical estimation, but an ever-varying quality, depending quantitatively on the elasticity of adjacent matter, and in the case of double refraction, actually varying in *two* or in *three* directions, *within the same substance:* it would be not more repugnant to reason to assume that the elasticity of a gas is one thing in a glass bottle, and another in one of brass; or that the specific gravity of silver is a function of the moon's age, or the melting point of gold dependent on the sun's zenith distance. Secondly, the fundamental ideas of inertia, energy, and "work" are inseparably associated with gravitation, and a contradiction of terms seems to be implied, in ascribing either inertia or energy, *i.e.*, the capability of doing work, to an *imponderable* particle, which is consequently destitute of attraction for any other particle in the universe.

The known enormous velocity, probably not less than 250,000 miles in a second, at which electricity travels through a copper conductor is complete evidence that ordinary matter is capable of transmitting *something* (whether matter or motion it signifies nothing for the present argument) at a considerably greater velocity than the waves of light and heat, why should not appropriate kinds of matter be assumed capable of transmitting these also? and if so, the need of the interstitial presence of ether ceases altogether; and it may with great advantage be excluded from the domains of ponderable palpable matter, by the very mild hypothesis that it is *not miscible* with air, any more than oil or *palpable* ether with water, but that it floats above the boundary surface of our atmosphere: this hypothesis is not repugnant to reason, nor adverse to physical experience. On this supposition it is no longer needed to impute to ether imponderability, *i.e.*, an exemption from the otherwise universal law of gravitation; it will then be imperceptible, only because it exists beyond the reach of observation: and thus imponderability will cease to be reckoned amongst the physical attributes of matter. Moreover, as there are no means of limiting the *possible* amount of molecular displacement in a medium so attenuated as ether must be, an amount of energy is conceivable sufficient to impart effective motion to indefinitely denser matter; and thus, without doing any violence to the fundamental principles of dynamics, this denizen of infinite space may be assumed competent to its divine mission of impart-

ing to material worlds those essentials to corporeal existence,—the very mainsprings of organic life,—light and heat.

The question then naturally arises—what becomes of the waves of heat and light, when they reach the confines of the atmosphere?—and is ordinary matter sufficient and effectual for their transmission? This question can be answered only from analogy, which appears to infer an affirmative.

That sound-waves are transmitted by air, and not by interstitial ether, is unquestionable; and if air be capable of transmitting 25,000 vibrations in one second, it will probably be difficult to assign any valid reason why the same medium is incapable of transmitting the far more rapid waves of heat and light; and if capable, then where lies the necessity for assuming the presence of another medium? Again, the refraction of sound, as demonstrated by the experiments of Hajech and Sondhaus (563, 564), is in exact accordance with the laws hitherto assigned to the refraction of light and heat. And it appears that the velocity of sound in solids and liquids is much greater than in air (545); in water it is nearly 5000 feet, and in iron nearly 17,000 feet in one second: is there, then, any known fact whatever that tends to assign a limit to the *possible* velocity of transmission of wave-motion through these and other material media?—if not, then the presence of ether, as generally assumed, cannot be deemed *essential* to the transmission of light and heat; and if not essential, why should the *interstitial-ether* hypothesis be any longer entertained?

> "Nec Deus intersit, nisi dignus vindice nodus
> Inciderit."

Moreover, Prof. Tyndall, to whom the progress of Dynamical Physics is indebted for many laborious and important researches, has observed that in various kinds of wood there is a remarkable harmony between their respective conductivities for sound and heat in three mutually perpendicular directions, namely, longitudinal, transverse-radial, and transverse-tangential (546): now although there is certainly no direct analogy between the conduction of heat, and the radiation of light and heat, beyond that of their common dynamic origin, a much closer analogy may nevertheless be traced through the phenomena of phosphorescence, fluorescence, and calorescence. It appears to be highly probable that the "calorescence" of a plate of platinized platinum, the phosphorescence by heat of the minerals Fluor and Apatite, and ordinary incandescence are analogous phenomena; differing only in the temperature (*i.e.*, the amount of thermic energy) at which heat-motion, impressed on the molecules of different substances, is imparted as light-motion to the surrounding medium. And some phenomena of phosphorescence present further evidence of the intimate relations existing between light, heat, and electricity: it

has been observed that Fluor may be rendered phosphorescent by a very moderate application of heat; but that it will not again phosphoresce under similar circumstances, until an electric spark has been repeatedly passed over its surface. But perhaps the closest analogy between the radiation of light and the conduction of heat may be traced in the observations of M. De Senarmont, who has found that, in plates of crystals cut in a direction coinciding with that of the optic axis, the relative conduction of heat, in directions parallel and perpendicular to the optic axis, is governed by precisely the same laws as those of optical elasticity, which determine the relations of the ordinary and extraordinary polarized rays: and moreover that in plates cut perpendicularly to the optic axis, thermic conductivity is, like optical elasticity, equal in all directions. It may also be remarked that the converse permeabilities to light and heat of a crystal of alum, and one of dark smoky quartz, or a smoked plate of rock-salt, present striking examples of the existing yet unknown differences of physical constitution, which are met with in the various kinds of matter, and which involve special capabilities of transmitting, or of arresting and diffusing, particular kinds of energy.

The correlation of the various forms of energy and their transmutations have been so well collated by Mr. Grove, and so frequently referred to in the preceding and subsequent pages, that repetition here would be wearisome; it will suffice to refer to the before-mentioned enormous magneto-electric engine designed for the illumination of lighthouses, and constructed also by Mr. Wilde of Manchester (911). Acting like those of Messrs. Wheatstone, Siemens, and Ladd, on a principle of reduplication, or self-reaction, it is a grand instance of the transmutation of energy; and it may here be cited as a good example of a series of successive conversions.

In long bygone ages the energies of solar light and heat were occupied in the development of woody tissue, and this became gradually converted into coal, perhaps without much gain or loss of energy. The dynamic energy arising from the collision of the molecules of carbon with those of atmospheric oxygen, in the act of combustion, *i.e.*, combination, is yielded up as thermic energy to the boiler of a steam-engine, and generates steam, the elastic force of which, through the medium of the engine, drives round the armatures of the electro-magnets. Dynamic becomes now converted into magnetic, and this again into electric energy, and an interrupted current of intense power is produced. This being transmitted between carbon electrodes, an immense amount of light and heat is produced by molecular friction at the point of great resistance to the passage of the current, and these are produced at the expense of electric energy, as proved by the loss of current; here, then, we have the final transmutation of electric into thermic

and photic* energy: the latter being so intense as to have thrown a shadow across the brightest sunbeam, and to produce an amount of illumination unattainable by any other known means. This entire series of transmutations may be viewed as a complicated process of evolving stored up sunshine in an intensified form, for occasional use.

Having sufficiently considered the physical, it now remains to review the moral aspect of the large questions that have been raised in the preceding pages. The Author cannot but feel that in thus seeking to simplify by generalization the conception of the powers of nature, and to unify their source, he may in some minds, misguided by the pride of human reason, unwittingly encourage the pantheistic tendencies of the present age; than which nothing can possibly be further removed from his desire, or design. Where, it may be asked, is the faintest shade of difference between modern pantheism and the nature-worship of the oldest times, save that the mode of culture may have been humanized by civilization? in both alike reason and the objects of sense are deified, the thing created is set up on the Creator's throne, and the light of revelation, with its priceless consequences, being invisible to the mere carnal eye of sense, is practically extinguished. The author would rather remonstrate openly with those who, conscious it may be of great intellectual power, have unfortunately been led to ignore all things divine, that are not cognizable by unaided reason, and to such he would say, in the emphatic words of the great Tishbite of old, "How long halt ye between two opinions? if the Lord be God, follow Him; but if Baal, then follow him:" and he would earnestly entreat them to reflect that between the two alternatives there can be *no compromise.*

The grand mysteries of Creation must of course be ignored by all those who have closed their eyes against all things not visible in the light of unaided reason; and accordingly it has not long since been asked before a large and intelligent audience, Whence came the first elephant? "did he fall from the sky (*i.e.*, from the interplanetary space)? did he rise moulded out of a mass of amorphous earth or rock? did he appear out of the cleft of a tree?"—to which, responding in the same key, the writer answers no:—nor yet from the endless transmutations either of a sign-post, or a gallows-tree;—nor even from the adaptive efforts of countless generations of huge boar-pigs, inheriting from their primæval ancestor a weakness for the green tufts that grow on tall and leafless tropical stems;—no!—that wonderful mechanism of interlacing muscular fibres, by which a boneless appendage can acquire almost the rigidity of an outstretched arm, and the prehensile sensibility of opposed digits, could only have come, and must have come direct, from the hand of an all-beneficent Creator.

* The Greek roots are generally adopted in all similar words.

If the impossibility of forming any definite conception of the creation of matter be urged as an objection to the ordinarily received Christian views of the Creation, the argument may be met by a candid admission of our entire ignorance of the nature of matter itself: what it *appears to our senses to be*, we know from its various characteristic properties; but what matter *really is*, we do not and we cannot know. But this knowledge is obviously essential to a precise conception of its creation.

It may by some be thought that these remarks are *extra vires* in a treatise on Physics, but the Author cannot ignore the apostolic injunction—" Whether ye eat or drink, or *whatsoever ye do*, do all to the glory of God;" and he feels that when such language has been publicly proclaimed, he would fail in his Christian duty if he failed to give equal publicity to his earnest and indignant protest.